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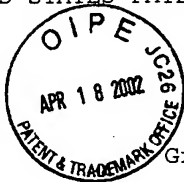
IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of

ARNAUD BOURGE ET AL

Serial No.: 10/082,860

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Title: METHOD OF TRANSCODING AND TRANSCODING DEVICE WITH EMBEDDED FILTERS

Commissioner for Patent
Washington, D.C. 20231

CLAIM FOR PRIORITY

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Sir:

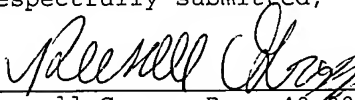
A certified copy of the European Application No.

01400588.8 filed March 6, 2001 referred to in the Declaration of the above-identified application is attached herewith.

Applicants claim the benefit of the filing date of said European application.

Respectfully submitted,

By


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Enclosure

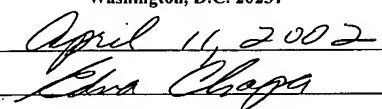
CERTIFICATE OF MAILING

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Die angehefteten Unterlagen stimmen mit der ursprünglich eingereichten Fassung der auf dem nächsten Blatt bezeichneten europäischen Patentanmeldung überein.

The attached documents are exact copies of the European patent application described on the following page, as originally filed.

Les documents fixés à cette attestation sont conformes à la version initialement déposée de la demande de brevet européen spécifiée à la page suivante.

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Patentanmeldung Nr. Patent application No. Demande de brevet n°

01400588.8

Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
p.o.

I.L.C. HATTEN-HECKMAN

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Blatt 2 der Bescheinigung
Sheet 2 of the certificate
Page 2 de l'attestation

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Application no.: 01400588.8
Demande n°:

Anmeldetag:
Date of filing: 06/03/01
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Anmelder:
Applicant(s):
Demandeur(s):
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5621 BA Eindhoven
NETHERLANDS

Bezeichnung der Erfindung:
Title of the invention:
Titre de l'invention:

Method of transmitting and transcoding device with embedded filters

In Anspruch genommene Priorität(en) / Priority(ies) claimed / Priorité(s) revendiquée(s)

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Remarques:

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Method of transcoding and transcoding device with embedded filters**5 FIELD OF THE INVENTION**

The present invention relates to a method of transcoding a primary encoded signal comprising a sequence of pictures, into a secondary encoded signal, said method of transcoding comprising at least the steps of:

- 10 - decoding a current picture of the primary encoded signal, said decoding step comprising a dequantizing sub-step for providing a first transformed signal,
- encoding, following the decoding step, for obtaining the secondary encoded signal, said encoding step comprising a quantizing sub-step.

The invention also relates to a corresponding device for carrying out such a method of transcoding.

- 15 This invention is particularly relevant for the transcoding of MPEG encoded video signals.

BACKGROUND OF THE INVENTION

- 20 Bit-rate transcoding is a technique which allows a primary video stream encoded at a bit-rate BR1 to be converted into a secondary video stream encoded at a bit-rate BR2 lower than BR1, the bit-rate reduction being performed in order to meet requirements imposed by the means of transport during broadcasting. A transcoding device as described in the opening paragraph is disclosed in the European Patent Application n° EP 0690 392 (PHF 94001) and is depicted in Fig. 1. Said device (100) for transcoding encoded digital
- 25 signals (S1) which are representative of a sequence of images, comprises a decoding channel (11,12) followed by an encoding channel (13,14,15). A prediction channel is connected in cascade between these two channels, and said prediction channel comprises, in series, between two subtractors (101,102), an inverse discrete cosine transform circuit IDCT (16), a picture memory MEM (17), a circuit for motion compensation MC (18) in view
- 30 of displacement vectors (V) which are representative of the motion of each image, and a discrete cosine transform circuit DCT (19).

SUMMARY OF THE INVENTION

- 35 It is an object of the invention to provide a method of transcoding and a corresponding device that allows a better quality of pictures for low bit-rate applications. The present invention takes the following aspect into consideration.

With the advent of home digital video recording of MPEG broadcasts, transcoders can be used in consumer devices to implement long play modes or to guarantee the recording time. However, the input signal to be transcoded has often been encoded at a variable bit-rate with a low average bit-rate. This is due to the generalization of statistical
5 multiplexing that allows broadcasters to put a lot of video programs in a multiplex in order to save the bandwidth. It is likely that a coarser re-quantization of the input signal, using a method of transcoding according to the prior art, will lead to conspicuous quantization artifacts. As a consequence, such a transcoding method is not adapted for low bit-rate applications.

10 To overcome this drawback, the method of transcoding in accordance with the invention is characterized in that it further comprises a filtering step between the dequantizing sub-step and the quantizing sub-step.

The transcoding method in accordance with the invention allows to implement filters in the transcoder of the prior art at a negligible cost. Those filters can be tuned to control
15 the static and dynamic resolution and also to perform noise reduction. For the same number of bits, the filtered transformed signal is encoded with a smaller quantization scale thus reducing visual artifacts such as blocking, ringing and mosquito noise.

In a first embodiment of the invention, the method of transcoding comprises a step of predicting a transformed motion compensated signal from a transformed encoding error
20 derived from the encoding step, said prediction step being located between the encoding and decoding steps, and is characterized in that the filtering step is a temporal filtering step for receiving the transformed motion compensated signal and the first transformed signal and for providing a filtered transformed signal to the quantizing sub-step.

Such a temporal filtering step allows to perform noise reduction using, for example,
25 a recursive filter. As a consequence, bits are only spent on the useful information contained in the picture and the picture quality is thus increased.

In a second embodiment of the invention, the method of transcoding also comprises a prediction step and is characterized in that the filtering step is a spatial filtering step for
30 receiving the first transformed signal and for providing a filtered transformed signal, said filtered transformed signal and the transformed motion compensated signal being provided to the quantizing sub-step.

Such a spatial filtering allows a reduction of the sharpness of the picture and decreases the possible source of ringing and mosquito noise.

35 The present invention also relates to a corresponding device for carrying out such a method of transcoding.

The present invention finally relates to a computer program product for a receiver, such as a digital video recorder or a set-top-box, that comprises a set of instructions, which, when loaded into the receiver causes the receiver to carry out the method of transcoding.

These and other aspects of the invention will be apparent from and will be elucidated with reference to the embodiments described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described in more detail, by way of example, with reference to the accompanying drawings, wherein :

- 10 - Fig. 1 is a block diagram corresponding to a transcoding device according to the prior art,
- Fig. 2 is a block diagram corresponding to a first embodiment of a transcoding device according to the invention, said device comprising a temporal filter circuit,
- Fig. 3 is a block diagram corresponding to a second embodiment of a transcoding device according to the invention, said device comprising a spatial filter circuit,
- 15 - Fig. 4 a block diagram corresponding to a third embodiment of a transcoding device according to the invention, said device also comprising a spatial filter circuit, and
- Fig. 5 a block diagram corresponding to a fourth embodiment of a transcoding device according to the invention, said device also comprising a spatial filter circuit and,
- 20 possibly, a temporal filter circuit.

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to an improved method of and a corresponding device for transcoding video encoded signals. It relates, more especially, to MPEG-2 encoded signals but it will be apparent to a person skilled in the art that said method of transcoding stays also applicable to any type of video signals encoded using a block-based technique such as, for example, those provided by MPEG-1, MPEG-4, H-261 or H-263 standards.

A transcoding device allows a primary encoded signal (S1) previously encoded with a first quantization scale and comprising a sequence of pictures, to be converted into a secondary encoded signal (S2) encoded with a second quantization scale.

Such a transcoding device comprises at least the following elements:

- a decoding unit comprising a variable length decoder VLD and a first dequantizer IQ for decoding a current picture of the primary encoded signal and for providing a first transformed signal,
- 35 - an encoding unit comprising a quantizer Q, a variable length encoder VLC for obtaining the secondary encoded signal, and a second dequantizer IQ,

- a prediction unit, between the encoding unit and the decoding unit, and comprising in series :
 - an inverse discrete transform circuit IDCT (an Inverse Discrete Cosine Transform in the case of MPEG),
 - 5 • a picture memory MEM,
 - a circuit MC for motion compensation in view of displacement vectors which are representative of the motion of each picture,
 - a discrete transform circuit DCT for predicting a transformed motion compensated signal (Rmc) from a transformed encoding error (Re) derived from the encoding
 - 10 unit,
 - an adder for determining a sum of the transformed motion compensated signal and a transformed signal (R1 or Rf),
 - a subtractor for determining the transformed encoding error from a difference between said sum and a second transformed signal (R2) provided by the encoding
 - 15 unit,
- a filter circuit, between the first dequantizer and the quantizer, for providing a filtered transformed signal (Rf).

Said filter circuit can be a temporal or a spatial filter circuit adapted to control the static and dynamic resolution and to perform noise reduction on a picture. The different

20 implementations of such filters are described in the following Figs. 2 to 5.

It will be apparent to a person skilled in the art that the result of the transcoding device is unchanged if the adder is replaced by another subtractor adapted to determine a difference between a transformed signal (R1 or Rf) and the transformed motion

compensated signal (Rmc) and if the first cited subtractor is adapted to determine the

25 transformed encoding error (Re) from a difference between the second transformed signal (R2) and the output of the other subtractor.

In a first embodiment of the invention, the transcoder implements a motion compensated temporal filter. Temporal filtering allows to reduce signals which are not

30 correlated from frame to frame. It can very effectively reduce noise when combined with motion compensation, as motion compensation tries to correlate the image content from frame to frame. In this embodiment, a recursive filter is implemented since it provides a better selectivity at lower cost.

A naive transcoding chain with a motion compensated recursive temporal filter

35 usually comprises in cascade :

- a decoder for providing motion compensated blocks D1 of decoded pictures from an input stream,

- a recursive temporal filter for providing filtered blocks D_f of decoded pictures, and
- an encoder for providing an output stream and motion compensated blocks D_2 of locally decoded pictures after encoding.

5 To reduce costs, the motion compensation in the encoder is re-used in the recursive temporal filter. Thus, the signal D_2 is fed back to said filter instead of D_f . The filtering equation of a motion compensated block $D_f(n, m)$ is then :

$$D_f(n, m) = (1 - \alpha) \cdot D_1(n, m) + \alpha \cdot MC(D_2(p(n)), V(n, m)), \quad (1)$$

where :

- n is the index of the current picture,
- m is the index of a block of said current picture,
- $V(n, m)$ is the motion associated with block m , of picture n ,
- $p(n)$ is the index of the anchor picture associated with image n ,
- MC is the motion compensation operator, and
- α is a positive scalar smaller than one that tunes the filter response.

15 An expression similar to equation (1) can be drawn for bidirectional motion compensation. However, without loss of generality, we shall restrict the demonstration to the unidirectional case. Note that intra encoded blocks cannot be filtered since no prediction is formed for them. Yet, intra encoded blocks in non intra pictures correspond most often to newly exposed regions that could not possibly be temporally filtered.

20 The naive transcoding chain can be simplified using the hypothesis that the motion compensation information is unchanged. To this end, the motion compensated block $D_1(n, m)$ is expressed as follows :

$$D_1(n, m) = M^t \cdot R_1(n, m) \cdot M + MC(D_1(p(n)), V(n, m)), \quad (2)$$

where :

- M is the 8×8 discrete cosine transform matrix,
- M^t is the corresponding transposed matrix, and
- $R_1(n, m)$ is the residue retrieved from the input bit-stream after variable length decoding VLC and dequantization IQ.

M is defined by equation (3) and is such that $MM^t = I$:

$$30 \quad M_{i,j} = \begin{cases} \sqrt{2}/4 & \text{if } i = 0, \\ \cos(i\pi(2j+1)/16)/2 & \text{otherwise.} \end{cases} \quad (3)$$

Then, the filtered block is encoded using the same motion compensation information. Let $R_f(n, m)$ be the corresponding residue :

$$R_f(n, m) = M \cdot D_f(n, m) \cdot M^t - M \cdot MC(D_2(p(n)), V(n, m)) \cdot M^t. \quad (4)$$

35 The residue is then quantized and dequantized again to compute the locally decoded pictures D_2 . Let $R_2(n, m)$ be the quantized and dequantized residue :

$$R2(n, m) = M \cdot D2(n, m) \cdot M^t - M \cdot MC(D2(p(n)), V(n, m)) \cdot M^t. \quad (5)$$

The equations (1) and (4) are combined so that R_f is derived directly from $D1$ and $D2$:

$$R_f(n, m) = (1 - \alpha) [M \cdot D1(n, m) \cdot M^t - M \cdot MC(D2(p(n)), V(n, m)) \cdot M^t]. \quad (6)$$

Combining the equation (2) with equation (6) gives :

$$R_f(n, m) = (1 - \alpha) [R1(n, m) + M \cdot MC(D1(p(n)), V(n, m)) \cdot M^t - M \cdot MC(D2(p(n)), V(n, m)) \cdot M^t]. \quad (7)$$

Since motion compensation is performed identically from $D1$ and from $D2$, the motion compensation operator MC can operate on the picture difference, i.e., on the error signal due to the transcoding operation. Defining $\delta D = D1 - D2$, equation (7) is rewritten as follows :

$$R_f(n, m) = (1 - \alpha) [R1(n, m) + M \cdot MC(\delta D(p(n)), V(n, m)) \cdot M^t]. \quad (8)$$

The error signal δD can be derived from the prediction errors, combining equations (5) and (6) :

$$\delta D(n, m) = M^t \left[\frac{R_f(n, m)}{1 - \alpha} - R2(n, m) \right] \cdot M. \quad (9)$$

Equations (8) and (9) define the transcoder structure depicted in Fig. 2. Said transcoder (200) comprises :

- a decoding channel comprising a variable length decoder VLD (11) and a first dequantizer IQ (12) for decoding a current picture of a primary encoded signal ($S1$) and for providing a first transformed signal ($R1$),
- an encoding channel comprising a quantizer Q (13), a variable length encoder VLC (14) for obtaining the secondary encoded signal ($S2$), and a second dequantizer IQ (15) for providing a second transformed signal ($R2$),
- a prediction channel comprising, in series :
 - a subtractor (201) for determining a transformed encoding error (Re) and whose negative input receives the second transformed signal,
 - an inverse discrete cosine transform circuit IDCT (16),
 - a picture memory MEM (17),
 - a circuit for motion compensation MC (18),
 - a discrete cosine transform circuit DCT (19) for predicting a transformed motion compensated signal (Rmc),
 - an adder (202) for providing a sum of the transformed motion compensated signal and the first transformed signal ($R1$) to the positive input of the subtractor,

- a temporal filter circuit W_t (21) for receiving said sum and for providing the filtered transformed signal (R_f) to the quantizer Q (13).

In an advantageous embodiment of the invention, the strength of the motion compensated recursive temporal filter is adjusted separately for each transformed coefficient $R_f[i]$, i.e., for each DCT sub-band. The transformed coefficient of rank i is multiplied by $W[i]$ = $1 - \alpha[i]$ such as :

$$R_f[i] = W[i] (R1[i] + Rmc[i]) \quad (10)$$

Thus, the noise reduction can be tuned to the spectral shape of the noise. It can also be decided not to filter low frequencies in order to avoid visible artifact in case of a bad motion compensation and in order to reduce the noise.

In the second and third embodiments of the invention, the transcoder implements a spatial filter. Spatial filtering is not so efficient to reduce the noise as motion compensated temporal filtering is. Yet, it can prevent block artifacts at low bit-rate, smoothing down sharp edges that would otherwise create ringing effects. It can also simplify complex patterns that would be otherwise randomly distorted from one picture to the other, resulting in the so-called mosquito noise.

Let us consider again the naive transcoding chain. The pixel domain filter shall have a granularity which is the same as the granularity of the decoder. Thus we consider a block-wise filter. Let $D1(n,m)$ be block m of picture n . The filtered block $D1(n,m)$ is computed as follows :

$$Df(n,m) = Fv(n) \cdot D1(n,m) \cdot Fh^t(n) \quad (11)$$

where $Fv(n)$ and $Fh(n)$ are matrices that define respectively the vertical and horizontal filtering within the block.

Combining the equation (11) with the equation (2), we find :

$$Df(n,m) = Fv(n) \cdot M^t \cdot R1(n,m) \cdot M \cdot Fh^t(n) + Fv(n) \cdot MC(D1(p(n)), V(n,m)) \cdot Fh^t(n) \quad (12)$$

If the filter is the same for a group of pictures, then $Fv(n) = Fv(p(n))$ and $Fh(n) = Fh(p(n))$. Thus, the following approximation can be given for equation (12) based on the assumption that block-wise filtering commutes with motion compensation :

$$Df(n,m) = Fv(n) \cdot M^t \cdot R1(n,m) \cdot M \cdot Fh^t(n) + MC(Df(p(n)), V(n,m)) \quad (13)$$

It follows that the block-wise filter can be applied to residue $R1(n,m)$ after an inverse discrete cosine transform IDCT. To implement the spatial filter in the transcoder, the residue $R1(n,m)$ needs to be substituted by :

$$Rf(n,m) = M \cdot Fv(n) \cdot M^t \cdot R1(n,m) \cdot M \cdot Fh^t(n) \cdot M^t \quad (14)$$

Even if the matrices $M \cdot F_v(n) \cdot M^t$ and $M \cdot F_h^t(n) \cdot M^t$ can be pre-computed, their computing seems to involve many operations. Said computing can be simplified for a class of block-wise filters for which the two matrices are diagonal. Such filters are symmetric filters with an even number of taps. In our embodiment, we consider normalized 3-tap symmetric filters since they are more suitable for small blocks. Such filters have a single parameter, denoted a . The corresponding pixel domain filtering matrix, $(F_{i,j})_{0 \leq i,j < 8}$, is defined by :

$$F_{i,j} = \frac{1}{2+a} \begin{cases} a & \text{for } i = j = 1 \text{ to } 6, \\ 1 & \text{for } i = j \pm 1, \\ 1+a & \text{for } i = j = 0 \text{ and } 7, \\ 0 & \text{otherwise.} \end{cases} \quad (15)$$

Then,

$$M \cdot F_{i,j} \cdot M^t = \frac{1}{2+a} \begin{cases} 2 \cos(i\pi/8) + a & \text{for } i = j \\ 0 & \text{otherwise.} \end{cases} \quad (16)$$

Thus, to implement filtering with horizontal parameter a_h and vertical parameter a_v , the residue $R1(n,m)$ needs to be weighted (component-wise) by $(Ws_{i,j})_{0 \leq i,j < 8}$ defined as follows :

$$Ws_{i,j} = \frac{2 \cos(i\pi/8) + a_v}{2 + a_v} \cdot \frac{2 \cos(j\pi/8) + a_h}{2 + a_h} \quad (17)$$

Fig. 3 shows a transcoder with spatial pre-filtering according to the second embodiment of the invention. Said transcoder (300) comprises :

- a decoding channel comprising a variable length decoder VLD (11) and a first dequantizer IQ (12) for providing a first transformed signal (R1),
- a spatial filter circuit Ws (31) for receiving said first transformed signal and for providing the filtered transformed signal (Rf),
- an encoding channel comprising a quantizer Q (13), a variable length encoder VLC (14) and a second dequantizer IQ (15) for providing a second transformed signal (R2),
- a prediction channel comprising, in series :
 - a subtractor (201) for determining a transformed encoding error (Re) and whose negative input receives the second transformed signal,
 - an inverse discrete cosine transform circuit IDCT (16),
 - a picture memory MEM (17),
 - a circuit for motion compensation MC (18),
 - a discrete cosine transform circuit DCT (19) for predicting a transformed motion compensated signal (Rmc), and
 - an adder (302) for providing a sum of said transformed motion compensated signal and the filtered transformed signal (Rf) to the positive input of the subtractor.

Fig. 4 is a transcoder according to the third embodiment of the invention, with spatial post-filtering whose weighting factors are $Ws_{i,j}$. Said transcoder (400) comprises :

- a decoding channel comprising a variable length decoder VLD (11) and a first dequantizer IQ (12) for providing a first transformed signal (R1),
- 5 - an encoding channel comprising a quantizer Q (13), a variable length encoder VLC (14) and a second dequantizer IQ (15) and further comprising an inverse filter circuit (42) for providing a second transformed signal (R2),
- a prediction channel comprising, in series :
 - a subtractor (201) for determining a transformed encoding error (Re) and whose
 - 10 negative input receives the second transformed signal,
 - an inverse discrete cosine transform circuit IDCT (16),
 - a picture memory MEM (17),
 - a circuit for motion compensation MC (18),
 - a discrete cosine transform circuit DCT (19) for predicting a transformed motion
 - 15 compensated signal (Rmc),
 - an adder (202) for providing a sum of said transformed motion compensated signal and the first transformed signal (R1) to the positive input of the subtractor, and
 - a spatial filter circuit Ws (41) for receiving said sum and for providing a filtered transformed signal (Rf) to the encoding channel.

20 Compared to pre-filtering, the spatial filtering is performed in the encoding part of the transcoder.

Fig. 5 is a transcoder according to the fourth embodiment of the invention, with spatial post-filtering. Said transcoder (500) comprises:

- 25 - a decoding channel comprising a variable length decoder VLD (11) and a first dequantizer IQ (12) for providing a first transformed signal (R1),
- an encoding channel comprising a quantizer Q (13), a variable length encoder VLC (14) and a second dequantizer IQ (15) for providing a second transformed signal (R2),
- a prediction channel comprising, in series a subtractor (201) for determining a
- 30 transformed encoding error (Re) and whose negative input receives the second transformed signal, an inverse discrete cosine transform circuit IDCT (16), a picture memory MEM (17), a circuit for motion compensation MC (18), a discrete cosine transform circuit DCT (19) for predicting a transformed motion compensated signal (Rmc), and an adder (202) for providing a sum of said transformed motion compensated
- 35 signal and the first transformed signal (R1) to the positive input of the subtractor.

Said transcoder further comprises a switch (52) having at least two positions. In a first position (a) of the switch, a spatial filter circuit Ws (51) is adapted to receive the output

of the adder and to provide a filtered transformed signal (Rf) to the quantizing circuit (13). In that case, and contrary to Figs. 3 and 4, the spatial filter circuit is not applied to every macroblocks contained in the current picture but is only applied to intra coded macroblocks contained in said picture. In a second position (b) of the switch, no filtering is applied : this position corresponds mainly to non intra coded macroblocks.

An alternative to this second position may be the position (c) which corresponds to a temporal filter circuit Wt (51), as described hereinbefore, and adapted to receive the output of the adder and to provide a filtered transformed signal (Rf) to the quantizing circuit (13). As a consequence of said alternative, temporal filtering is applied, as usual, to non intra coded macroblocks and spatial filtering is applied to intra coded macroblocks.

Such a method may improve the picture quality, especially when the noise level is low.

Moreover, the intra coded macroblocks may be filtered with various filtering levels or even non filtered at all, depending on a macroblock-based measurement (BM) such as, for example, a noise measurement. For example, the current intra coded macroblock is labeled as:

- a 'noisy' macroblock if the macroblock-based measurement is higher than a first threshold,
- an 'edge' macroblock of a noisy area if the macroblock-based measurement is higher than a second threshold and lower than the first threshold,
- a 'not noisy' macroblock if the macroblock-based measurement is lower than the second threshold.

The spatial filter circuit is adapted to choose a suitable filter to be applied to the current intra coded macroblock as a function of its label ('not noisy', 'noisy' or 'edge' macroblock). For example, if the macroblock is labeled as 'not noisy', no filtering is done; if the macroblock is labeled as 'noisy', a medium filtering is performed ($a_h = a_v = 8$ for example); if the macroblock is labeled as 'edge', a soft filtering is performed ($a_h = a_v = 16$ for example).

In the previously described transcoders (200,300,400,500), the filtering is performed on the dequantized data, which results in a better accuracy. Best results, so far, were obtained for the combination of spatial filtering of pictures and temporal filtering of predicted pictures. Successive filtering blocks Wt or Ws can also be merged into a single block whose weighting is the product of the individual weightings, without departing from the scope of the invention.

The drawings and their description hereinbefore refer both to a transcoding device and a method of transcoding, a functional block of a diagram corresponding to a circuit of

said device or a step of said method, respectively. They illustrate rather than limit the invention. It will be evident that there are numerous alternatives, which fall within the scope of the appended claims. In this respect, the following closing remarks are made.

5 There are numerous ways of implementing functions by means of items of hardware or software, or both. In this respect, the drawings of Fig. 2 to 5 are very diagrammatic, each representing only one possible embodiment of the invention. Thus, although a drawing shows different functions as different blocks, this by no means excludes that a single item of hardware or software carries out several functions. Nor does it exclude that an assembly of items of hardware or software or both carry out a function. For example, the filtering step
10 can be combined with the quantization step, thus forming a single step without modifying the method of transcoding in accordance with the invention.

Said method of transcoding can be implemented in several manners, such as by means of wired electronic circuits or, alternatively, by means of a set of instructions stored in a computer-readable medium, said instructions replacing at least a part of said circuits
15 and being executable under the control of a computer or a digital processor in order to carry out the same functions as fulfilled in said replaced circuits. For example, it is possible to implement the transcoding method using an integrated circuit which is suitably programmed. A set of instructions contained, for example, in a computer programming memory may cause the integrated circuit to carry out the different steps of the transcoding method. The set of
20 instructions may be loaded into the programming memory by reading a data carrier such as, for example, a disk. The set of instructions can also be made available by a service provider via a communication network such as, for example, the Internet.

Any reference sign in the following claims should not be construed as limiting the
25 claim. It will be obvious that the use of the verb "to comprise" and its conjugations does not exclude the presence of any other steps or elements besides those defined in any claim. The word "a" or "an" preceding an element or step does not exclude the presence of a plurality of such elements or steps.

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CLAIMS

- 1 A method of transcoding a primary encoded signal (S1) comprising a sequence of pictures, into a secondary encoded signal (S2), said method of transcoding comprising at least the steps of :
- 5
- decoding a current picture of the primary encoded signal, said decoding step comprising a dequantizing sub-step (12) for providing a first transformed signal (R1),
 - encoding, following the decoding step, for obtaining the secondary encoded signal,
- 10 said encoding step comprising a quantizing sub-step (13), characterized in that said method of transcoding further comprises a filtering step between the dequantizing sub-step and the quantizing sub-step.
- 2 A method of transcoding as claimed in claim 1 comprising a step of predicting a transformed motion compensated signal (Rmc) from a transformed encoding error (Re) derived from the encoding step, said prediction step being located between the encoding and decoding steps, characterized in that the filtering step is a temporal filtering step (21) for receiving the transformed motion compensated signal and the first transformed signal (R1) and for providing a filtered transformed signal (Rf) to the quantizing sub-step.
- 15
- 20
- 3 A method of transcoding as claimed in claim 2, characterized in that the temporal filtering step (21) is intended to use a recursive filter such as :
- $$Rf[i] = (1 - \alpha[i]) (R1[i] + Rmc[i]),$$
- where Rf[i], R1[i] and Rmc[i] are transformed coefficients comprised in the transformed signals (Rf, R1, Rmc) and $\alpha[i]$ is a filter coefficient comprised between 0 and 1.
- 25
- 4 A method of transcoding as claimed in claim 1 comprising a step of predicting a transformed motion compensated signal (Rmc) from a transformed encoding error (Re) derived from the encoding step, said prediction step being located between the encoding and decoding steps, characterized in that the filtering step is a spatial filtering step (31) for receiving the first transformed signal (R1) and for providing a filtered transformed signal (Rf), said filtered transformed signal and the transformed motion compensated signal being provided to the quantizing sub-step (13).
- 30
- 35
- 5 A method of transcoding as claimed in claim 1 comprising a step of predicting a transformed motion compensated signal (Rmc) from a transformed encoding error (Re) derived from the encoding step, said prediction step being located between the encoding

and decoding steps, characterized in that the filtering step is a spatial filtering step (41) for receiving the transformed motion compensated signal and the first transformed signal (R1) and for providing a filtered transformed signal (Rf) to the quantizing sub-step (13), the encoding step further comprising an inverse filtering sub-step (42).

5

6 A method of transcoding as claimed in claim 1 comprising a step of predicting a transformed motion compensated signal (Rmc) from a transformed encoding error (Re) derived from the encoding step, said prediction step being located between the encoding and decoding steps, characterized in that the filtering step is a spatial filtering step (51) for receiving the transformed motion compensated signal and the first transformed signal (R1) and for providing a filtered transformed signal (Rf) to the quantizing sub-step (13), said spatial filtering step being only applied to intra coded macroblocks contained in the current picture.

10

15 7 A method of transcoding as claimed in claim 6, characterized in that it further comprises a detection step for giving a label to a current macroblock, the spatial filtering step being adapted to apply a filter to the current macroblock as a function of said label.

8 A device for transcoding a primary encoded signal (S1) comprising a sequence of pictures, into a secondary encoded signal (S2), said device comprising at least :

20 - a decoding unit for decoding a current picture of the primary encoded signal, said decoding unit comprising a dequantizing circuit (12) for providing a first transformed signal (R1),

- an encoding unit for obtaining the secondary encoded signal, said encoding unit

25 comprising a quantizing circuit (13),

characterized in that said transcoding device further comprises a filter circuit between the dequantizing circuit and the quantizing circuit.

25

9 A transcoding device as claimed in claim 8 comprising a prediction unit for predicting a transformed motion compensated signal (Rmc) from a transformed encoding error (Re) derived from the encoding unit, said prediction unit being located between the encoding unit and the decoding unit, characterized in that the filter circuit is a temporal filter circuit (21) for receiving the transformed motion compensated signal and the first transformed signal (R1) and for providing a filtered transformed signal (Rf) to the quantizing circuit (13).

35

10 A transcoding device as claimed in claim 8 comprising a prediction unit for predicting a transformed motion compensated signal (Rmc) from a transformed encoding error (Re)

derived from the encoding unit, said prediction unit being located between the encoding unit and the decoding unit, characterized in that the filter circuit is a spatial filter circuit (31) for receiving the first transformed signal (R1) and for providing a filtered transformed signal (Rf), said filtered transformed signal and the transformed motion compensated signal being provided to the quantizing circuit (13).

11 A transcoding device as claimed in claim 8 comprising a prediction unit for predicting a transformed motion compensated signal (Rmc) from a transformed encoding error (Re) derived from the encoding unit, said prediction unit being located between the encoding unit and the decoding unit, characterized in that the filter circuit is a spatial filter circuit (41) for receiving the transformed motion compensated signal and the first transformed signal (R1) and for providing a filtered transformed signal (Rf) to the quantizing circuit (13), the encoding unit further comprising an inverse filter circuit (42).

12 A transcoding device as claimed in claim 8 comprising a prediction unit for predicting a transformed motion compensated signal (Rmc) from a transformed encoding error (Re) derived from the encoding unit, said prediction unit being located between the encoding and decoding units, characterized in that the filter circuit is a spatial filter circuit (51) for receiving the transformed motion compensated signal and the first transformed signal (R1) and for providing a filtered transformed signal (Rf) to the quantizing circuit (13), said spatial filter circuit being only applied to intra coded macroblocks contained in the current picture.

13 A transcoding device as claimed in claim 12, characterized in that it further comprises a detection circuit for giving a label to a current macroblock, the spatial filter circuit being adapted to apply a filter to the current macroblock as a function of said label.

14 A computer program product for a digital video recorder that comprises a set of instructions, which, when loaded into said digital video recorder, causes the digital video recorder to carry out the method as claimed in claim 1 to 7.

15 A computer program product for a set-top-box that comprises a set of instructions, which, when loaded into said set-top-box, causes the set-top-box to carry out the method as claimed in claim 1 to 7.

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Method of transcoding and transcoding device with embedded filters**ABSTRACT**

The present invention relates to a method of transcoding (200) a primary encoded signal (S1) into a secondary encoded signal (S2). Said method of transcoding comprising at least a step of decoding a current picture of the primary encoded signal, said decoding step comprising a dequantizing sub-step (12) for providing a first transformed signal (R1), an encoding step, following the decoding step, for obtaining the secondary encoded signal, said encoding step comprising a quantizing sub-step (13), and a step of predicting a transformed motion compensated signal (Rmc) from a transformed encoding error (Re) derived from the encoding step, said prediction step being located between the encoding and decoding steps. Said method of transcoding further comprises a filtering step (21), between the dequantizing sub-step and the quantizing sub-step, for obtaining a better quality of pictures for low bit-rate applications.

Use: MPEG transcoders, digital video recorders or set-top-boxes

Reference: Fig. 2

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1/3

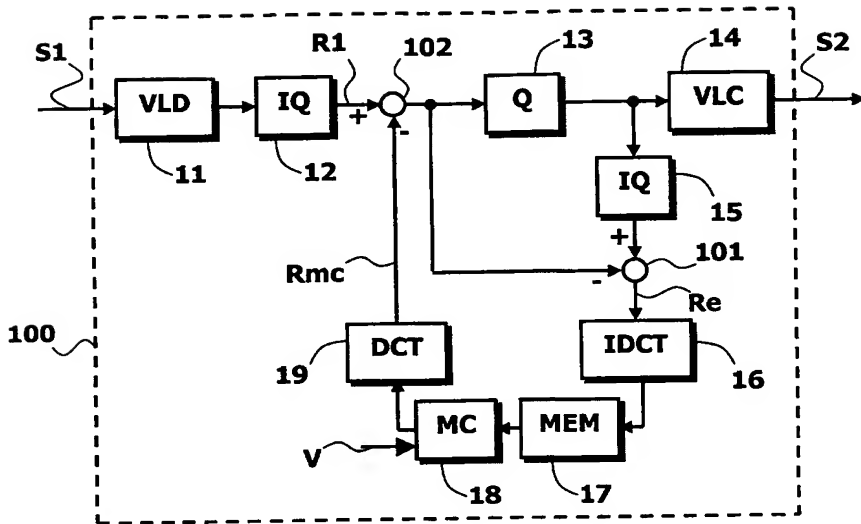


FIG. 1

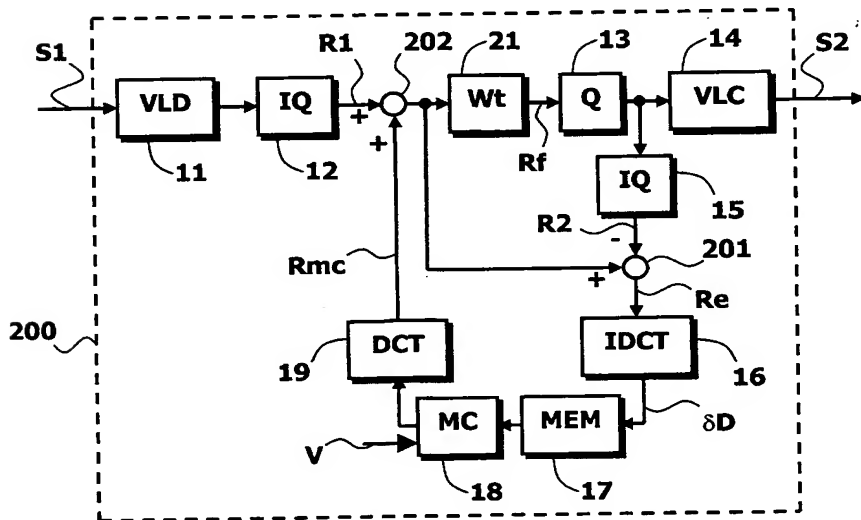


FIG. 2

2/3

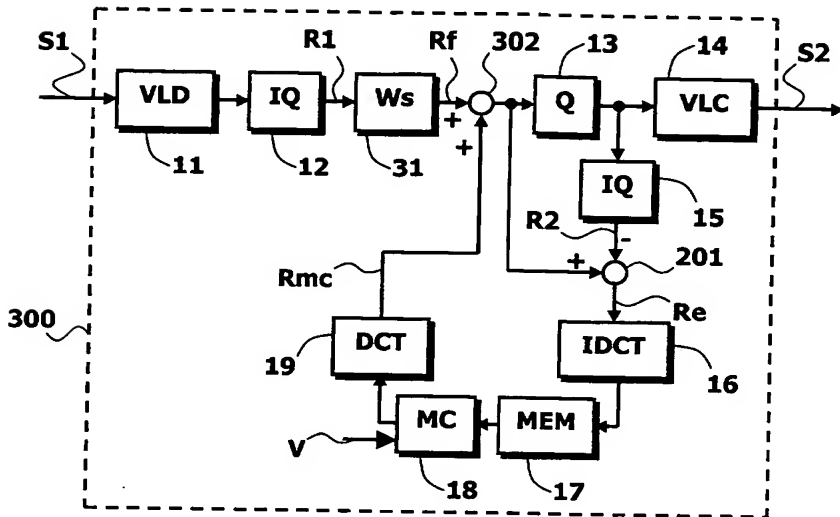


FIG. 3

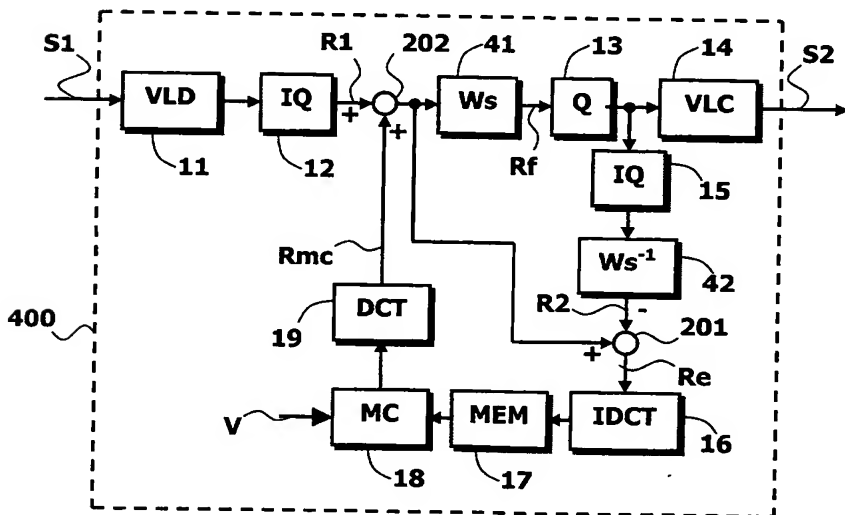


FIG. 4

3/3

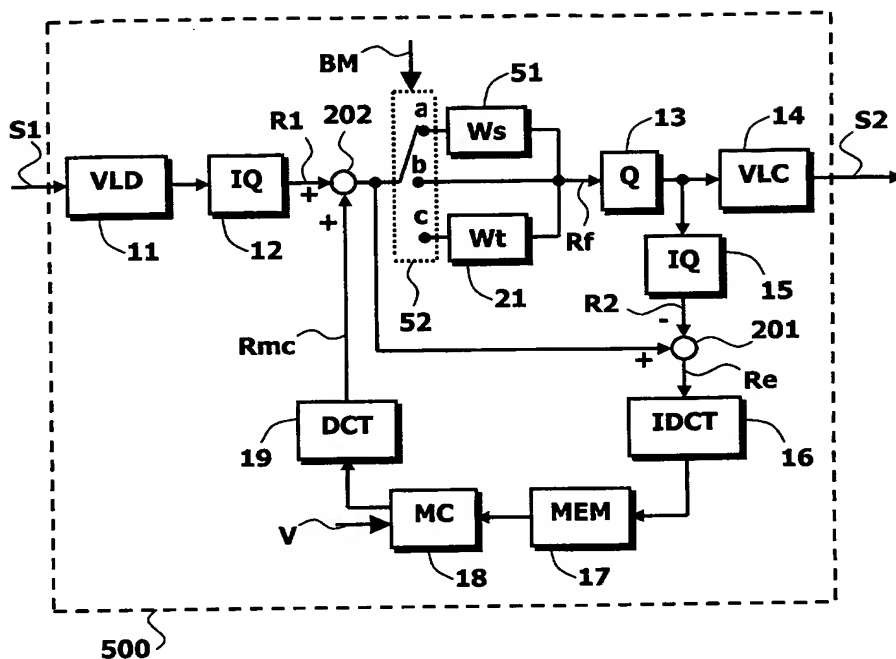


FIG. 5

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